THE FLASH FLOOD AND INTENSE RAINFALL EXPERIMENT: *LESSONS LEARNED AND FUTURE PLANS*

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The U.S. Weather Research Program
Better Weather Forecasts for the Nation

When it Rains, it Pours…

- According to NOAA, flooding results in ~ $8 billion in damages and ~89 fatalities per year
- WPC E… …nfall

Nashville, 2010 — Boulder, 2013

- WPC M…
  - Respo… …heavy ra… …e disc… …rred fro… … 9 April 2013
  - Meso… …tation d…
    - Event…
    - Highl… … rainfall may l… …oding *in th…*


THE TENNESSEAN

6 PAGES OF COVERAGE

OVERWHELMED

Eleven dead in 5 counties | Historic flood upends lives | Cumberland keeps rising


BUFFS' BELL FEELING GOOD, Sports 1C

Daily Camera

Levy leaving Colorado Legislature, Local 1B | Syria to offer weapons data, World View 2A

100-YEAR FLOOD

President Barack Obama approves federal disaster aid

Flooding claims at least two lives in Boulder, Jamestown

Dueling weather systems swamp rainfall records

Storm qualifies as 100-year flood event as creek levels rise

More flood coverage

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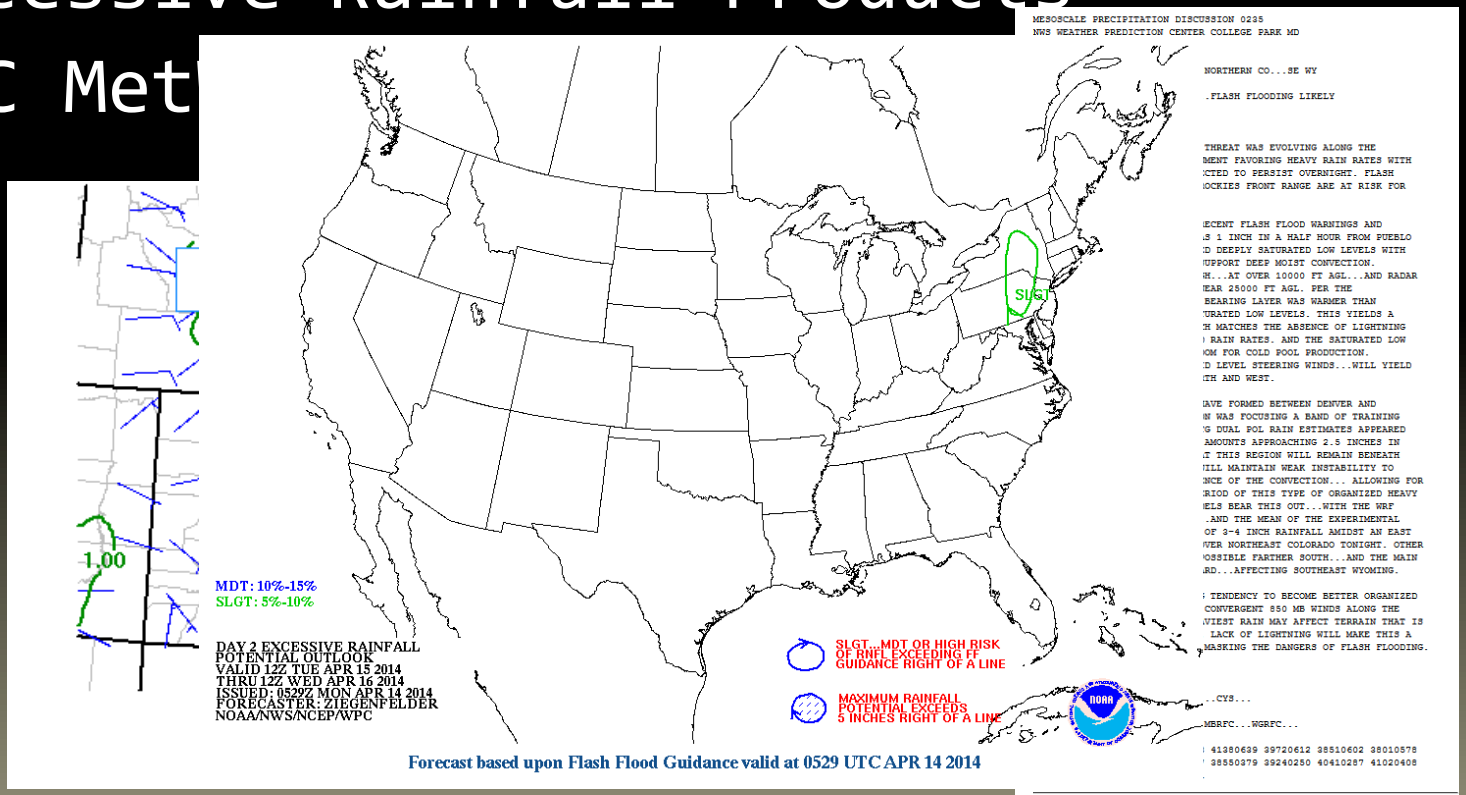
When it Rains, it Pours…

- According to NOAA, flooding results in ~$8 billion in damages and ~89 fatalities per year
- Excessive Rainfall Products
- WPC Met



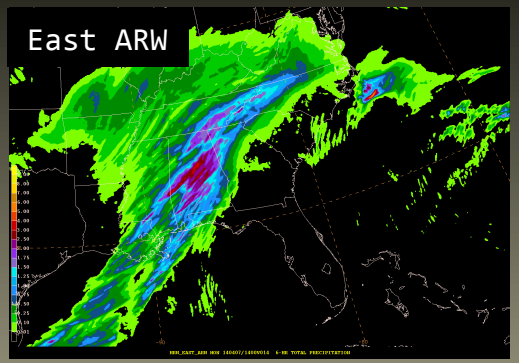
Flash Flood Forecasting: Challenges

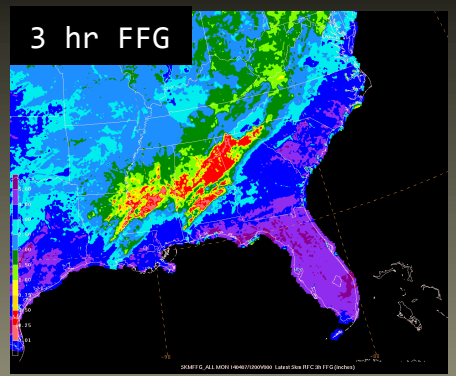
- The details of convection are hard to predict
  - Hires models do well in showing that convection is likely to happen
  - Struggle with the details
    - Timing, location, QPF amounts
- Hydrologic response is also difficult
  - How will precipitation be received by the land surface?
  - Small scale, very sensitive to changes in space
  - As of now, Flash Flood Guidance (FFG) provides the best way to gauge hydrologic response

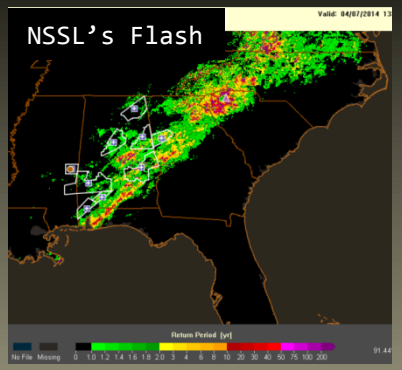
Flash Flood Forecasting: Challenges

Need to explore techniques to improve short term QPF and flash flood forecasts

- What to learn:
  - The value of hi-res deterministic guidance
  - The value of probabilistic guidance
    - Can hi-res ensemble probabilities be helpful in flash flood forecasting?
    - What needs to be done to maximize the effectiveness of the guidance?
  - The value hydrologic information
  - Are flash flood forecasts reliable in the 1-6 hour time frame?







Developing Guidance: How Do we Maximize What we Have?

- Use hi-res models to generate probabilistic information to assess flash flood threat

Hi-res ensembles can provide a variety of solutions

What if FFG is 2" in 3 hours?

Max 3 hr QPF

1.4"	2.4"	.78"
2.3"	1.8"	2.7"
3.7"	4.3"	2.8"

Developing Guidance: How Do we Maximize What we Have?

- Use hi-res models to generate probabilistic information to assess flash flood threat
  - QPF Probabilities
  - Couple with FFG: QPF > FFG probabilities

Hi-res ensembles can provide a variety of solutions

What if FFG is 2" in 3 hours?

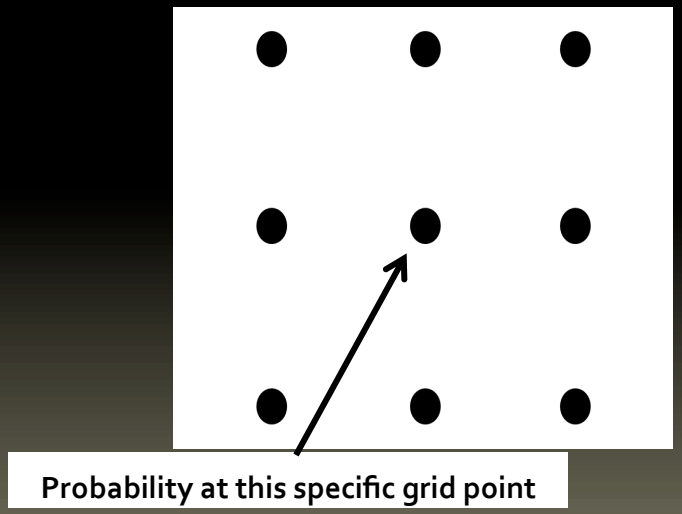
Is the threat really zero??

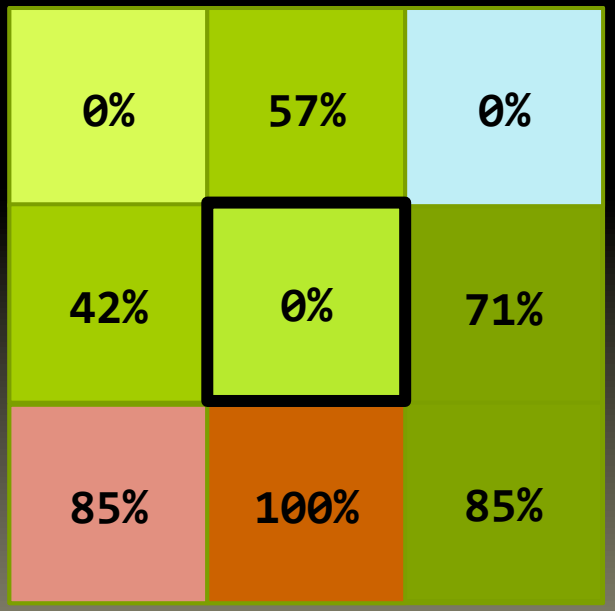
Prob 3 hr QPF > 2"

0%	57%	0%
42%	0%	71%
85%	100%	85%

Developing Guidance: Neighborhood Maximum Probabilities

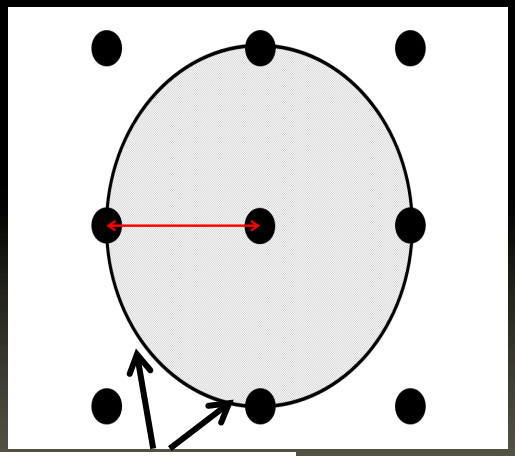
- Probability of an event happening within a certain distance of a grid point





Developing Guidance: Neighborhood Maximum Probabilities

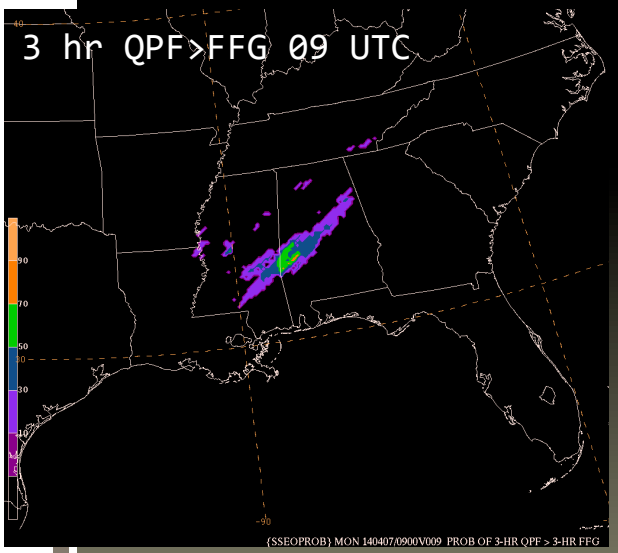
- Probability of an event happening within a certain distance of a grid point
  - Replace the value at a grid point with the maximum value within a radius (e.g. 40 km)

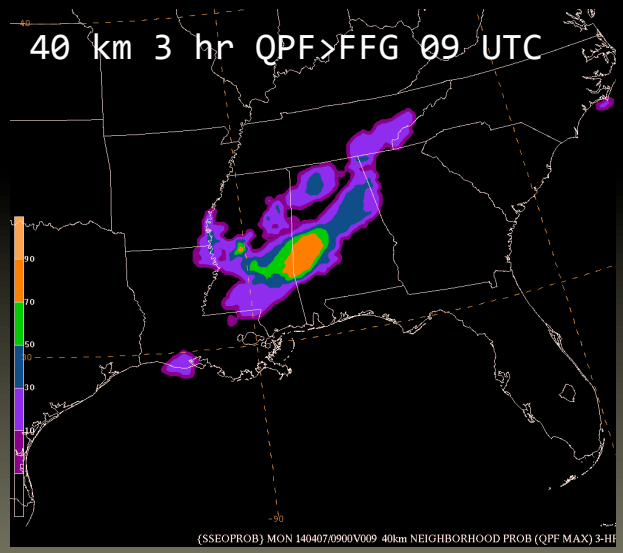


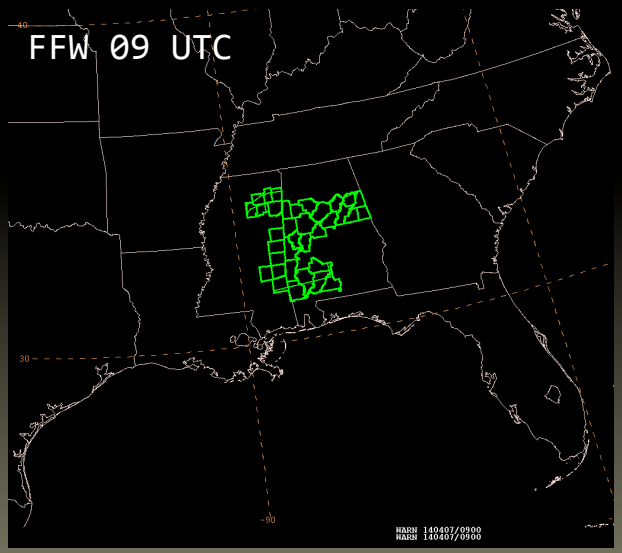
29%	71%	42%
57%	85%	85%
85%	100%	100%

Developing Guidance: Neighborhood Maximum Probabilities

- Probability of an event happening within a certain distance of a grid point
  - Replace the value at a grid point with the maximum value with a radius (e.g. 40 km)

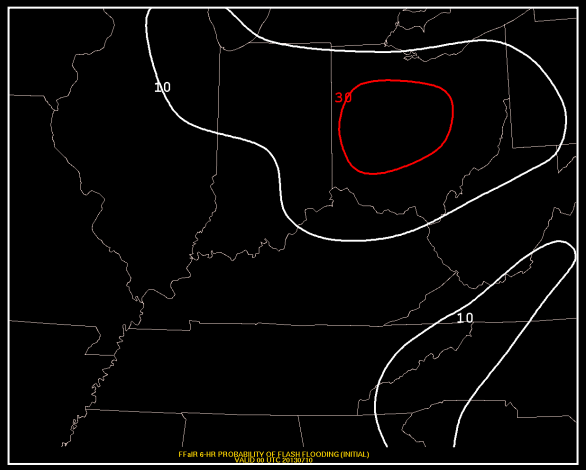


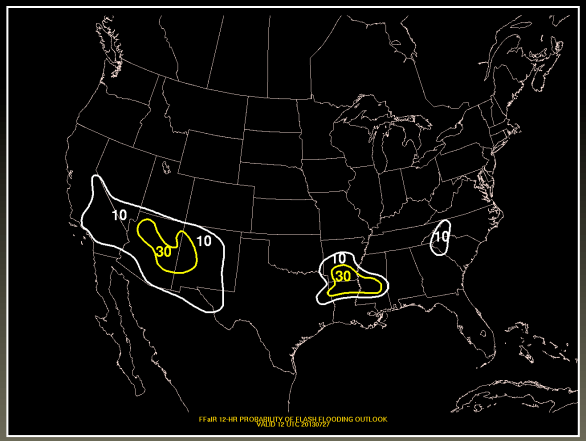




Flash Flood and Intense Rainfall Experiment (FFaIR): July 8 – 26, 2013

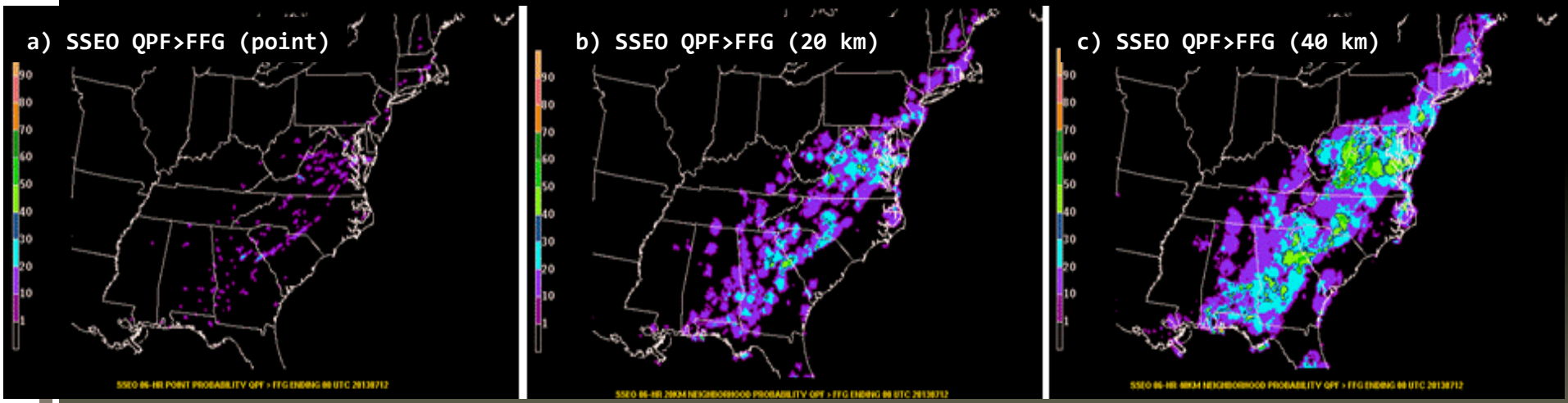
- 26 participants representing operations, research, and academia
  - 8 remote participants
- Daily Activities
  - 12 hr probabilistic precipitation forecast (12 – 00 UTC)
    - Probability of exceeding 1”
  - 6 hr probabilistic flash flood forecast (18 – 00 UTC)
    - Prelim
    - Update
  - 12 hr probabilistic flash flood outlook forecast (00 – 12 UTC)
  - Subjective Evaluation



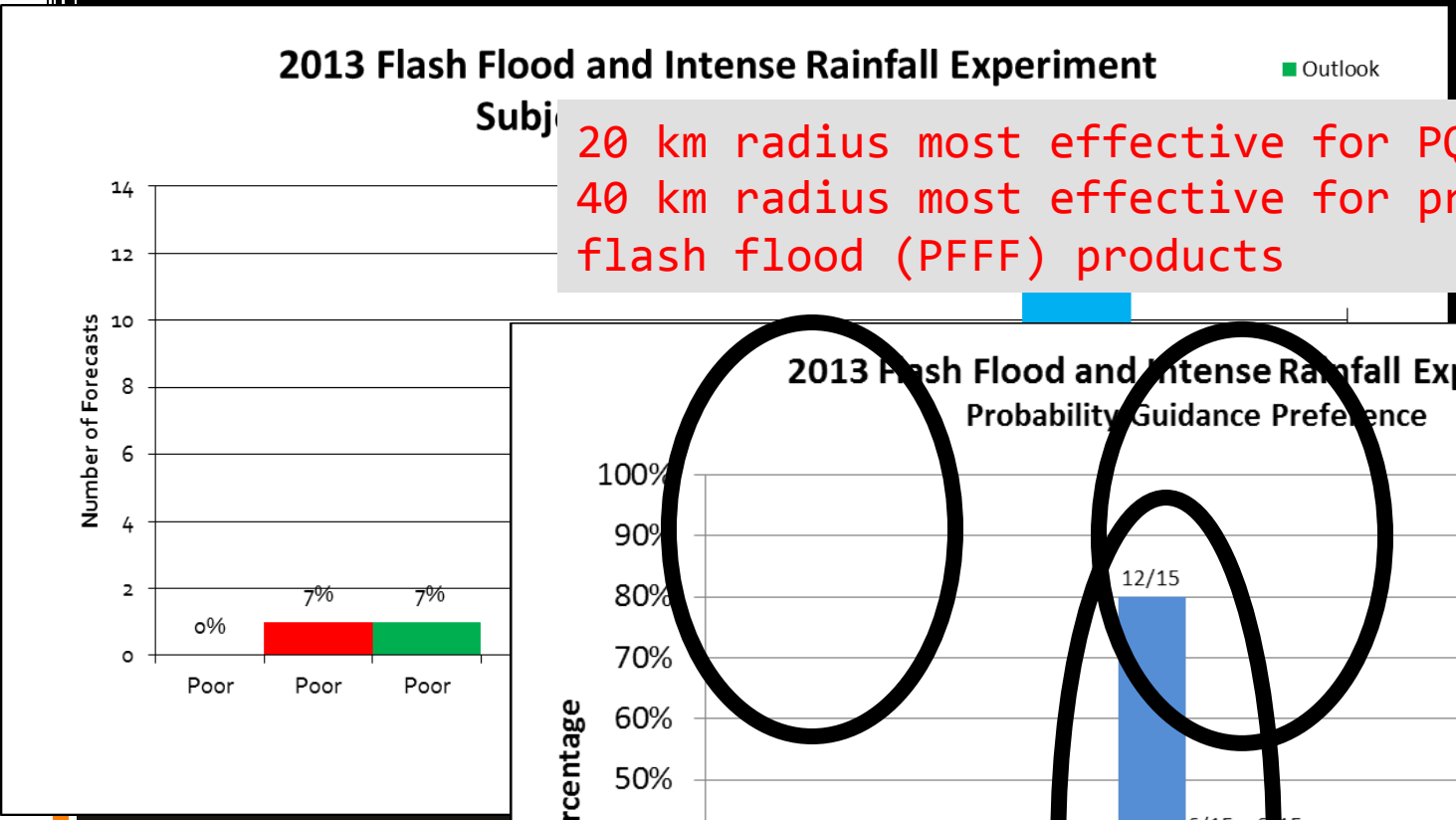


FFaIR: Testing and Evaluation

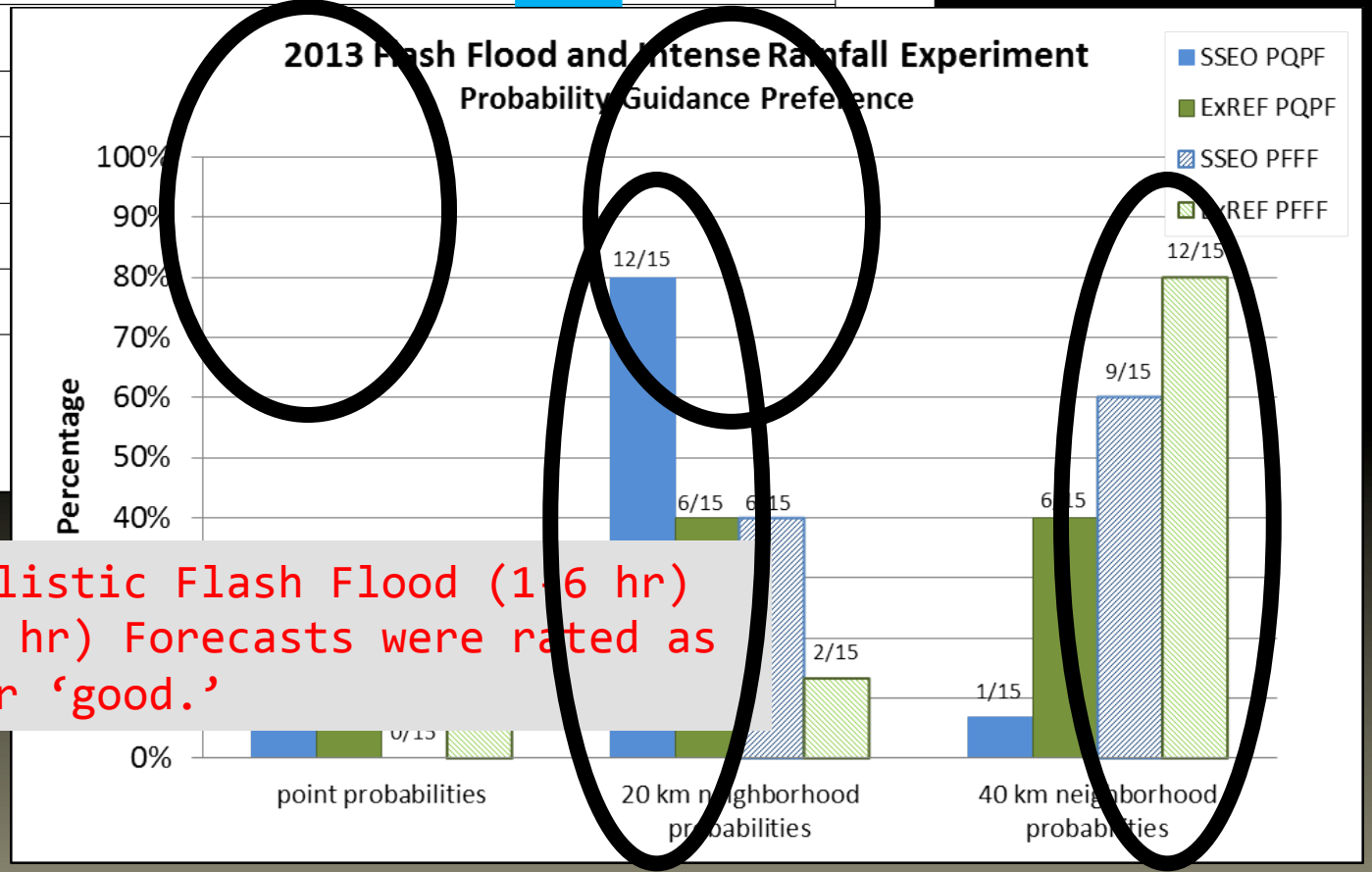
- Created QPF exceedance N-hood max probabilities
  - Storm Scale Ensemble of Opportunity (SSEO)
  - Experimental Regional Ensemble Forecasting System (ExREF)
    - QPF > 1” & 3”
    - QPF > FFG



FFaIR: Subjective Results



20 km radius most effective for PQPF products, 40 km radius most effective for probability of flash flood (PFFF) products



~94% of Probabilistic Flash Flood (1-6 hr) and Outlook (12 hr) Forecasts were rated as either ‘fair’ or ‘good.’

Lessons Learned: Guidance

- High resolution (convection-allowing) guidance can provide valuable information about the potential for flash flooding *before* event begins
- Probabilities of QPF > FFG provide valuable forecast guidance
  - Neighborhood probabilities can be a particularly useful forecast tool – account for spatial uncertainty in both QPF and hydrologic response
- Flash flood guidance is useful for assessing national vulnerability to flash flooding, but has limitations
  - Different methods used at different RFCs
  - Data latency due to varying issuance times
  - Multiple time periods – 1 hr, 3 hr, 6 hr
  - Complex terrain presents unique challenges

Full report available at: http://www.wpc.ncep.noaa.gov/hmt/FFaIR_2013_final_report.pdf

Lessons Learned: Overall

- Gap in understanding between the meteorological and hydrologic aspects of flash flood forecasting
  - Heavy rain ≠ flash flooding
  - Meteorological confidence ≠ hydrologic confidence
    - Slight spatial and temporal variations change antecedent conditions, basin response characteristics, etc.
- Forecasters successfully able to identify regions with a flash flood threat 6 – 12 hours in advance

Full report available at: http://www.wpc.ncep.noaa.gov/hmt/FFaIR_2013_final_report.pdf

Ongoing Work: 2014 FFaIR

- We crawled. Now it's time to walk.
  - Introduce upgrades to neighborhood probabilities
    - Reduce the data latency of FFG in QPF > FFG products → 06 and 18 UTC cycles
    - Create exceedance ratios
      - QPF > .75 FFG
  - Customize SSEO
    - Add HRRR as a member(s)
  - Investigate use of other hi-res guidance
- Continue to explore flash flood forecasting beyond the near-term 6 hour period
  - Explore changes to our Excessive Rainfall Product